RANGE TEST VALIDATION CLOUD TRACKING SYSTEM

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RANGE TEST VALIDATION CLOUD TRACKING SYSTEM

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ABSTRACT
The Range Test Validation System (RTVS) includes a constellation of five AIRIS-WAD standoff multispectral sensors oriented around a 1000x1000 meter truth box at a range of 2700 meters. Column density data derived from these sensors is transmitted in real-time to a command post using a wireless network. The data is used with computed tomographic methods to produce 3-D cloud concentration profiles for chemical clouds traversing the box. These concentration profiles are used to provide referee capability for the evaluation of both point and standoff sensors under test. The system has been used to monitor chemical agent simulants released explosively as well as continuously through specialized stacks. The system has been demonstrated to accurately map chemical clouds with concentrations as low as 0.5 mg/m^3 at spatial and temporal resolutions of 6 meters and 3 seconds.[1] Data products include geo-referenced cloud mass centroids and boundaries as well as total cloud mass.

1. INTRODUCTION

The improvement of ground test validation capability has recently been targeted by the Joint Program Executive Office for Chemical and Biological Defense (JPEO-CBD) as an important technical objective. The objective of PSI's effort reported in this paper is the development of a system that is capable of providing accurate three dimensional concentration distributions of chemical agent simulant clouds released on test ranges. Such a system enhances the ability to validate new chemical and biological sensing technology, as well as provides a better understanding of the fate and transport of chemical releases through chemical reaction models.[1] PSI's RTVS system has the capability to generate 3-D concentration profiles once every 10 seconds and offers specific data presentation approaches that enable rapid evaluation of the chemical releases and/or performance of systems under test. In this paper, we present specific results from RTVS release observations conducted at Dugway Proving Grounds.

2. SYSTEM ARCHITECTURE AND DEMONSTRATED CAPABILITY

The RTVS system is comprised of five AIRIS-WAD standoff multispectral sensors, a central command station and a wireless network subsystem. A conceptual diagram of the system is shown in Figure 1. The AIRIS-WAD sensors are oriented around a 1000 x 1000 meter truth
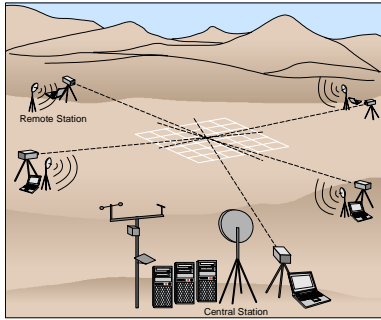
Figure 1. Imaging sensor constellation for tomographic chemical plume mapping.
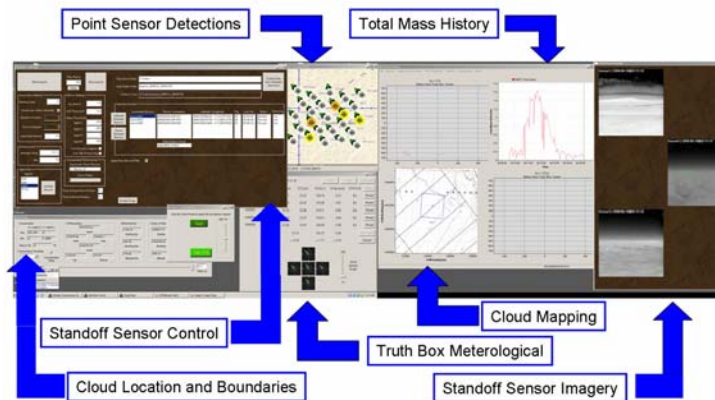

Figure 2. Image of command post real-time remote control and data display screen indicating system features.

box at a range of 2700 meters. Each of the sensor remote sites are equipped with directional antennas that provide comm.unication with the central command station, thus allowing both remote control of the sensors, as well as data telemetry capability. The system uses commercial 802.11g based wireless capability employing FIPS 140-2 compliant encrypted radios to enable system control and transmission of data at DPG in accordance with their wireless policy. This capability was validated during the RTVS 2008 tests conducted at Target-S in June 2008. The central command control unit is based on a Graphical User Interface (GUI) that allows functional control of the remote sensors. The GUI also serves as a display for received individual sensor detection views, as well as the resulting chemical cloud track, concentration contours, and total detected mass as a function of time. Figure 2 shows a screen print of the data control and display system from the command post indicating this capability, as well as the ability to co-visualize data from the SPIDAR point sensor array also deployed to the tests.

The technical basis of the RTVS approach is as follows. Each AIRIS-WAD multispectral sensor provides radiance measurements of sufficient accuracy that the species-specific column densities of chemical clouds are determined with only a couple of degrees effective temperature difference between the vapor and the background.[1] The calculated column density profiles observed in the FOV of each sensor along with the associated 2-D detection maps are transmitted to the central command computer via the wireless network. A Computed Tomography (CT) inversion method is employed to produce geo-referenced mass centroids along with three dimensional concentration profiles of the cloud based on the two-dimensional line density measurements. The tomography algorithm is employed on the processing node of the central command station and is based on an algebraic reconstruction technique utilizing a Maximum Likelihood Expectation Maximization (MLEM) procedure in order to estimate chemical cloud concentration values associated with each voxel in the 3-D grid.

The RTVS system and the technical basis of its approach have been successfully tested at Target-R, Target-S, and V-Grid at Dugway Proving Grounds in 2006, 2007 and 2008. The system has been used to monitor chemical agent simulants (TEP, AA, MeS, R134a, and SF_6) released explosively as well as continuously through specialized stacks. The system has been demonstrated to accurately map chemical clouds with concentrations as low as 0.5 mg/m^3 at spatial and temporal resolutions of 6 meters and 3 seconds.[1] An example of the system's data products is shown in Figure 3. These include geo-referenced 3-D concentration profiles as a function of time, ground level concentration contours, total detected mass in the 3-D grid, and center of mass tracking of the cloud as it moves across the grid.

3. CONCLUSIONS

Through the development and implementation of the RTVS system, we have demonstrated the methodology and the ability to use passive infrared multispectral imaging to track and quantify chemical clouds via computed tomography (CT). The CT algorithm has been demonstrated to be capable of 3-D reconstruction of chemical clouds using 2-D column density data with as few as 3 sensors. Errors associated with the reconstruction methods are less than 20% when using 3 sensors and less than 10% when using 5 sensors even for complex chemical cloud concentration distributions. The statistical method for the calculation of chemical cloud column densities from sensor radiometric data has been
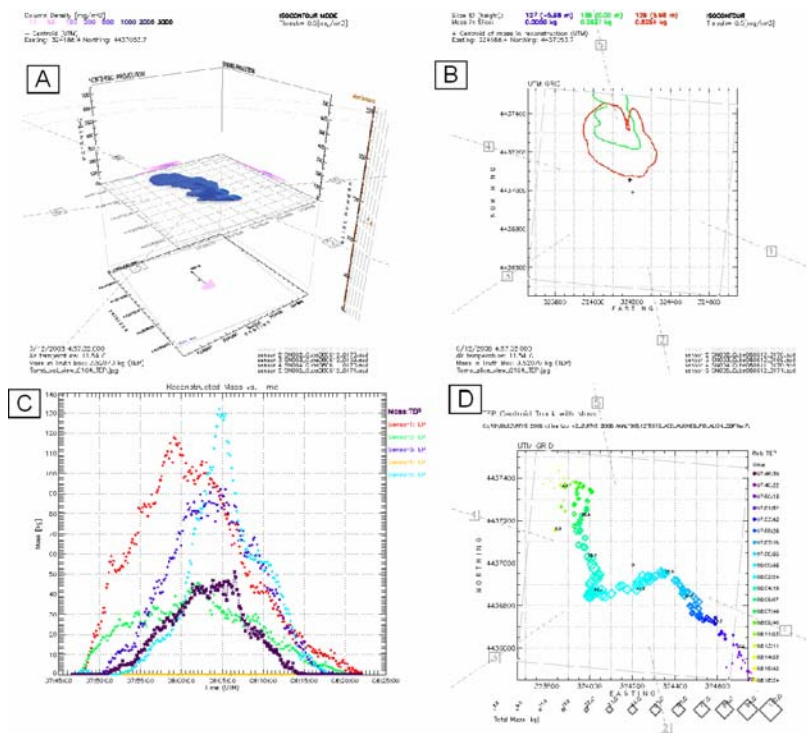

Figure 3. RTVS data products: A. Geo-referenced 3-D concentration profile with associated column density projections. B. Ground level geo-referenced concentration contours – 0.5 mg/m^3 contour at 5m (green) and 10 m (red) above the ground. C. Total mass (kg) in the grid as a function of time. D. Center of mass cloud track as it moves across the grid.

experimentally demonstrated to produce chemical plume column density values that are accurate to within ~ 10% or less.[1] The primary source of error in the field measurements is the determination of the local air temperature. The total concentration measurement error for the RTVS field data is estimated to be ~ 30%.[1] Field data results demonstrate the capability of the system to determine 3-D concentration profiles that account for as much as ~80% of the total known mass of material released. However, the release of large amounts of simulant into small volumes during low inversion layers produced optically thick clouds. The simulant column densities in these clouds could not be determined using our established radiative transfer model. This effect led to an under-estimation of the mass detected by the system.

4. ACKNOWLEDGMENTS

5. REFERENCE

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